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of

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for

PERSONAL IDENTIFICATION SYSTEM

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PERSONAL IDENTIFICATION SYSTEM

BACKGROUND OF THE INVENTION

The present invention relates to a technology
for identifying a person using a living body, and more
particularly to a technology for identifying a person

5   using a finger vein pattern.

Today, the typical personal identification
technology is fingerprint identification. However, the
problem is that other person's fingerprint is easily
obtained, for example, a criminal's fingerprint is

10 taken in the scene of a crime, and therefore a finger-
print may be forged. This problem leads to the
development of personal identification technologies
other than fingerprint identification. For example,
JP-A-7-21373, laid-open January 24, 1995, discloses a

15 personal identification technology thorough the use of
a finger blood vessel pattern, and JP-A-10-295674,
laid-open November 10, 1998, discloses a personal
identification technology through the use of a vein
pattern on the back of a hand. These technologies

20 shine a light on a finger or on the back of a hand,
capture the reflected light or transmitted light,
extract the blood vessel pattern from the captured
image, and compare the captured blood vessel pattern
with the previously-registered blood vessel pattern to

25 identify a person.

SUMMARY OF THE INVENTION

However, there are some problems in implementing a personal identification system that uses finger vein patterns.

One of the problems is the reproducibility of a captured image. Although a conventional personal identification system has positioning parts such as a pin or a grasping bar for stabilizing the imaging region, an error in the imaging region is unavoidable, for example, when a finger is rotated or moved in the plane or when a finger is rotated on its major axis. Therefore, it is difficult to completely match a registered vein pattern with a vein pattern obtained at identification time, with the result that the performance of identification is reduced. In particular, on a fully-non-contact system on which the finger is not put on something for fixing, a registered vein pattern and a captured vein pattern may differ largely and this difference further reduces the performance of identification.

Another problem is a light source. A conventional personal identification system has no function to adjust the amount of light from the light source. This generates several image-quality problems such as a blurred outline of a captured image, a lack in sharpness, and a low contrast. These problems require a complex image-processing algorithm for correction and sometimes result in the low performance of identifica-

tion.

According to one aspect of the present
invention, means described below is used for improving
reproducibility. First means is an algorithm for
5 correcting an error detected during image processing
that is executed for matching an imaged finger blood
vessel pattern with a registered pattern. This correc-
tion prevents the performance of identification from
being degraded.

10 Second means is a three-dimensional imaging
of a living body from various angles using a plurality
of imaging devices. Even if a registered vein pattern
was imaged from only one direction, that is, the
registered pattern is two-dimensional data, the finger
15 may be placed freely when imaged for identification.
Therefore, even if there is an error in the imaging
region, one of the plurality of images may be selected
for use in matching. This prevents the performance of
identification from being degraded. It is also
20 possible to register three-dimensional vein patterns as
patterns to be registered by imaging the vein pattern
from a plurality of directions. In this case, one of
the plurality of registered vein patterns is selected
for matching. This also prevents the performance of
25 identification from being degraded even if there is an
error in the imaging region.

Combining the first means with the second
means further increases the performance of identifi-

cation.

A light source with means for optimizing the amount of light at imaging time is used as the light source. This configuration optimizes the amount of

5   light from the light source to make the quality of a captured image best.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram showing an example of the configuration of a system that captures the blood

10   vessel image of a living body using an optical method.

FIG. 2 is an external view of a personal identification system in an embodiment of the present invention.

FIGS. 3A and 3B are diagrams showing a low-

15   contact finger positioning method.

FIG. 4 is a diagram showing a light source composed of arranged light-emitting devices.

FIG. 5 is a diagram showing a three-dimensional imaging method using the three-dimensional

20   arrangement of imaging devices.

FIG. 6 is a flowchart showing a procedure for capturing a finger image in the embodiment of the present invention.

FIG. 7 is a diagram showing the positioning

25   of fingers at identification time when air is jetted.

FIG. 8 is a diagram showing an identification device using air jet used in an embodiment of the

present invention.

FIGS. 9A, 9B, and 9C are diagrams showing the sterilization method used on a contact identification · device.

5 FIG. 10 is a diagram showing the overview of processing from finger image capturing to identification in the embodiment of the present invention.

FIG. 11 is a diagram showing a procedure executed from finger image capturing to identification 10 in the embodiment of the present invention.

FIGS. 12A-12G are diagrams showing a first example of the creation of an image to be registered and an image to be authenticated in the embodiment of the present invention.

15 FIGS. 13A, 13B, and 13C are diagrams showing a second example of the creation of an image to be registered and an image to be authenticated in the present invention of the present invention.

FIG. 14 is a diagram showing a first example 20 of the method for normalizing identification processing results in the embodiment of the present invention.

FIG. 15 is a diagram showing a second example of the method for normalizing identification processing results in the embodiment of the present invention.

25 DETAILED DESCRIPTION OF THE EMBODIMENTS

(First embodiment)

FIG. 1 is an example of the basic configura-

tion of a personal identification system. FIG. 2 shows an embodiment of a personal identification system according to the present invention. The system comprises a light source unit 101 that shines a light

5 on a finger, an imaging unit 103 that captures the image of a finger, and an imaging processing unit 104 that processes captured image data. As the light source, a semiconductor light source, such as an LED (Light Emitting Diode), is usually used because of its

10 responsiveness and controllability. A CCD camera is used as the imaging unit. A personal computer is conveniently used as the imaging processing unit 104 that captures an image into the computer via the interface such as an image capture board. The imaging

15 processing unit 104 performs processing necessary for identifying a captured image. Numeral 201 indicates a window through which a light from the light source transmits. An automatic shutter may be provided on the window to prevent a light from being leaked from the

20 surrounding part of the finger to ensure accuracy in image processing. An automatic shutter may also be provided separately between the light source and the finger. Numeral 202 indicate pins that fix the imaging region. These pins are optional. If there is no pin,

25 the system is a fully non-contact system. The imaging unit 103 captures a vein pattern image formed by the light transmitted through the finger.

As a vein pattern for use in personal

identification, it is more preferable to use the vein
pattern of a palm-side finger than to use the vein
pattern of a back-side finger. This is because the
vein pattern of the back-side finger, which is always
5 exposed externally, is more likely to be stolen. In
this embodiment, the system always images the vein
pattern of the palm-side finger.

FIG. 3A is a diagram showing the fingers
exposed to the light source unit 101 shown in FIG. 1,
10 as viewed from the front. FIG. 3B is a diagram showing
the positional relation among light-emitting devices
301 constituting the light source, positioning pins
205, a finger 302, and an imaging device 303, as viewed
from the tip of the finger. Numeral 304 indicates a
15 transmitted light.

A plurality of light-emitting devices, which
make up the light source, are arranged according to the
shape of a finger, as shown in FIG. 4. Although near-
infrared, high-intensity light-emitting diodes (LEDs)
20 are used as the light source, a laser beam may also be
used. Numerals 401, 402, 405, and 406 are the front
views of many types of light source. Numeral 401
indicates the shape of a light source made up of a
plurality of conventional mold-type near infrared
25 light-emitting diodes (near-infrared LEDs) arranged
linearly. Because each of the plurality of light-
emitting devices indicated by numeral 401 is round, the
brightness of the light source is uneven. To solve

this problem, the round edges of the plurality of mold-type LEDs are removed to form the light source in the shape indicated by numeral 402. Numeral 407 is the front view, and numeral 408 is the cross sectional

5 view, of an LED whose edges have been removed. The shaded areas indicated by numeral 407 are the areas that are removed. The view indicated by numeral 403, a cross sectional view of the light source indicated by numeral 402, indicates the light source formed by

10 arranging a plurality of LEDs each in the shape indicated by numerals 407 and 408. This arrangement eliminates unevenness in the source light and increases the packing density and the light source intensity. Numeral 405 is an example of a light source made up of

15 a plurality of chip-type LEDs arranged in the plane. In any case, a plurality of LEDs are arranged to detect the location of a finger based on the image monitored by the imaging unit, and the light source elements to be turned on are selected to form a light source

20 according to the thickness and the length of a finger.

FIG. 6 shows the procedure for capturing a finger image. As the light source, a weak light is kept on at all times (601). The system checks if a finger is exposed to the weak light (602) and, if a

25 finger is present, detects the location of the finger (603). The presence and the location of the finger are detected based on the pixel value data of the monitor image. Based on the location data of the detected

finger, the system decides which elements of the light source to be turned on (604). In addition, the system acquires the pixel data of the monitor image (605) to optimize the amount of light to be supplied from the

5 light source.

The procedure for optimizing the amount of light is as follows. When human being's finger or toe is imaged, the light transmission factor is highest in joints. Therefore, the system detects a joint from the

10 light intensity profile of a finger in the major axis in the image data and uses the maximum intensity value as the intensity value (B) of the joint. This value is compared with the reference value (A) of intensity that is previously set. If A−B<0, the light source is

15 subjected to a feedback to reduce the input current to the light source. If A−B>0, the current input to the light source is increased. When A−B=0, the system ends the adjustment of light intensity, captures the image, and starts image processing. Performing this process-

20 ing for each light-emitting device optimizes not only the amount of light but also the area of the light source. In this case, the light source with the configuration composed of chip-type, small LEDs arranged in the plane, such as the one indicated by

25 numeral 405 in FIG. 4, is best. This configuration is effective for shining a light on a finger whose thick- ness and length vary greatly.

The method described above adjusts the light

source output to optimize the light intensity. Alternatively, adjusting the time during which the light stays on may also optimize the light intensity.

5 To optimize the amount of light, it is required that the joint be identified. Two sample procedures for identifying the joint will be described. In one procedure, a portion with a relatively high light-intensity value is detected in the image profile of a blood vessel pattern of a finger, imaged through 10 the use of transmitted light, to identify the joint of the finger. Then, a feedback is effected such that no pixel reaches the intensity value of 255 in the 8-bit dynamic range. In another procedure, an image to which a spatial low-pass filter is applied in the major axis 15 direction of a finger in the captured image is evaluated, and the amount of light of the light source striking the joint is adjusted. Any of the procedures described above forms a light source with a spatial intensity distribution.

20 The above-described configuration for automatically adjusting the amount of light is suitable for capturing a high-contrast blood vessel image. Adjusting the amount of light significantly increases the quality of a blood vessel image, allowing person 25 identification through image-to-image operation of captured images to be performed smoothly.

With a previously registered finger blood vessel as the template, personal identification

operation is performed through the calculation of
correlation to find a similarity between the blood
vessel pattern image of a finger imaged at authentica-
tion time and the template. The calculation of

5   correlation is a monotone increasing calculation in
which an output value increases in proportion to the
degree of matching of two-dimensional array elements.
Most typically, a two-dimensional convolution calcula-
tion (formula 1) is used.

10
$$z(k1, k2) = \sum_{m}^{m} \sum_{n}^{n} x(i, j)y(k1+1-i, k2+1-j)$$ (Formula 1)

$$(k1 = 1, 2, \cdots m+n-1, k2 = 1, 2, \cdots m+n-1)$$

One to ten fingers, usually up to all fingers
and toes may be registered. Depending upon the
required security level, the number of fingers to be
compared may be increased. In some cases, a non-finger

15 blood vessel image may also be used with a finger
image.

FIG. 10 is a block diagram showing the
personal identification procedure executed based on the
image of a detected finger. Personal identification

20 processing is divided roughly into two: registration
processing and authentication processing. Registration
processing, blocks 1000-1001, is processing in which a
database 100 is created based on the images registered
at registration time. Authentication processing,

25 blocks 1002-1005, is processing in which a person is

accepted or rejected based on the calculation of correlation between an image that is input for identification and a registered image.

During registration processing, the image

5   detecting means captures a person's finger image to be registered (block 1000). At the same time, registration image creation processing, which will be described later, is performed to create a finger-vein emphasized image and the created image is registered (block 1001).

10 On the other hand, during authentication processing, the personal information receiving means receives a person's ID (block 1002) and, at the same time, the registered image corresponding to the received ID is selected from the database (block 1003). In addition,

15 the image detecting means captures an identfee's image to be authenticated (block 1004) and, at the same time, authentication image creation processing, which is similar to registration image creation processing and will be described later, is performed to create a blood

20 vein emphasized image (block 1005), and the calculation of correlation between the captured image and the registered image is executed.

Then, the result of the calculation of correlation is evaluated, and the authentication result

25 indicating whether or not he/she is an identical person is output. Most typically, a two-dimensional convolution calculation is used as the calculation of correlation. In this case, even if the finger is translated

in the image plane, the distribution obtained as a
result of the two-dimensional convolution operation is
also translated with no change in size and shape.
Therefore, the evaluation of similarity between these
5   two images automatically corrects errors generated by
the translation in the image plane. In addition,
taking advantage of the fact that the convolution
operation between two data units is equivalent to the
inverse Fourier transformation of the product of the
10   Fourier-transformed data units, two-dimensional Fast
Fourier Transform (hereinafter called FFT) may be used
to speed up the calculation of correlation.

FIG. 11 is a block diagram showing the image
operation procedure when FFT is used to speed up the
15   calculation of correlation. Finger-edge extraction and
image-rotation processing (block 1101) is performed for
the captured image to be registered or for the captured
image to be authenticated. During this processing, the
finger edge is extracted and, based on the extracted
20   edge, the image is rotated so that the finger inclina-
tion becomes constant. Even when the physical location
of the finger is inadequate, this processing corrects
an error in the rotation in the image plane and
precisely locates the finger in the image space. This
25   processing, combined with the characteristics of the
two-dimensional calculation of correlation described
above, corrects errors associated with finger movement
operations (both translation and rotation) in the image

place and correctly locates the finger in the image
space.

The image to be registered and the image to
be authenticated, for which finger-edge extraction and
5   image-rotation processing has been performed, are each
converted to a finger-vein emphasized image (block
1102), and the two-dimensional FFT operation is
executed for the converted result (block 1103). The
result generated for the former image is registered.
10   The result generated for the latter image is multiplied
by the registered image selected based on the received
ID (block 1104). Then, two-dimensional fast inverse
Fourier transformation (Inverse FFT, hereinafter called
IFFT) is performed for the result (block 1105) to
15   produce the correlation distribution of the registered
image and the image to be authenticated. As described
above, the same image processing is performed for
blocks 1101 to 1103 during registration image creation
processing (block 1001) and during authentication image
20   creation processing (block 1005).

The personal identification system may
include a light source which shines a light on the
imaging region of a living body, an imaging unit which
detects a transmitted light from the imaging region to
25   image the living body, and an imaging processing unit
which extracts the blood vessel pattern of the living
body from the image converted by the imaging unit and
compares the pattern with a previously-registered blood

vessel pattern, wherein the image processing unit may comprises means for correcting an error between the registered blood vessel pattern and the imaged blood vessel pattern.

5   FIG. 12A is a block diagram describing in detail an example of the blood vessel emphasizing processing procedure. FIGS. 12B-12D are the general views of a finger image generated by each processing procedure.

10   An input image is divided roughly into a finger 120, an edge 121, and a surrounding part 122. In general, the image also includes various noises 123 that must be removed. In FIG. 12A, blocks (1201)- (1203) execute the procedure for extracting the edge of

15 a finger, blocks (1204)-(1206) execute the procedure for extracting an image corresponding to the background (back-trend) that is the part where no finger vein pattern is present, and blocks (1207)-(1211) execute the procedure for removing the back-trend from the

20 original image to extract only the necessary vein pattern.

        In response to a captured finger image (block 1200), a high-cut filter filters out small components such as noises 123 (block 1201) and emphasizes only

25 relatively large components such as the edge. Then, the procedure executes directional differentiation (block 1202) to give an edge-enhanced image (FIG. 12C).

        As shown in the image in FIG. 12C, the edge

121 in the edge enhanced image is enhanced and has a
large pixel value. Based on the pixel value, the
procedure performs edge detection processing to obtain
only the location information on the edge 121 (block

5 1203). Then, based on the location information on the
detected edge, the procedure produces an image (FIG.
12D) generated by clipping out only the finger 120 from
the original image shown in FIG. 12B (block 1204).

        In the image shown in FIG. 12D, the average

10 of the pixel values outside the finger is made equal to
the average of the pixel values inside the finger.
Without this averaging operation, the finger edge
component emphasized by finger the edge emphasizing
processing would affect the operation, preventing

15 personal identification operation through the vein
pattern from being performed properly.

        When the average of the pixel values inside
the finger is shifted to 0, the pixel value of 0 is
inserted into the surrounding part 122 of the image

20 shown in FIG. 12D. Then, after an image (FIG. 12E) is
created by extraporation of the values of the surround-
ing part 122 of the image shown in FIG. 12D in the
vertical direction by use of the values of the edge 121
(block 1205), only the large component, that is, the

25 back-trend, is extracted with a high-cut filter (block
1206). In the block 1205, extrapolation is performed
to prevent the high-cut filter in the block 1206 from
unintentionally emphasizing the pixel value near the

edge 121.

Next, after creating a difference image
between the original image (FIG. 12B) and the back-
trend image (block 1208), the clipped-out image (FIG.

5   12F) of the difference image is obtained based on the
detected edge location. The difference corresponds to
a part processed by a low-cut filter. This processing
removes the back-trend component generated by a light
transmitted through muscles or fat tissue or by

10 diffused lights. Therefore, an image where only the
blood vessel component is emphasized, such as the one
shown in FIG. 12F, is obtained.

Finally, according to the inclination of the
finger obtained from the detected edge location, the

15 image is rotated such that the finger is inclined at a
fixed angle, typically, at an angle of 0 degree (FIG.
12G) (block 1209). This image is output as the image
to be registered or as the image to be authenticated
(block 1210).

20   FIG. 15 is a block diagram showing the
authentication procedure that is executed after the
image to be authenticated is obtained by the procedure
in FIG. 12. The calculation result of correlation
between the registered image and the image to be

25 authenticated is normalized by the formula shown below
(formula 2) (block 1503), followed by the extraction of
the maximum value M of the distribution (block 1504).

$$Cab(x,y)/\left(\sqrt{Caa(x,y)} \times \sqrt{Cbb(x,y)}\right) \quad \text{(Formula 2)}$$

where, Cab(x,y) is the correlation distribution of the registered image and the image to be authenticated. Caa(x,y) and Cbb(x,y) represent a sum of squares of

5 respective pixel data of a registered image and a sum of squares of respective pixel data of an image to be authenticated, respectively.

If the calculated maximum correlation value M of the registered image and the image to be authenti-

10 cated is larger than the threshold Mo, the identifee is regarded as valid and is accepted (block 1009). If the value M is less than the threshold Mo, the identifee is not regarded as valid and is rejected (block 1010). The threshold Mo should be statistically calculated in

15 advance by entering sample images. When the average of pixel values inside the finger is shifted to the value of 0, the value of Mo ranges from 0.45 to 0.55. However, the value is not limited to this range.

If a person is not acknowledged, he or she

20 must re-enter data, such as finger image capture data, to make a re-authentication request a predetermined number of times. For example, a person who is successfully acknowledged is allowed to access managed data or areas. On the other hand, a person who is not

25 acknowledged makes a re-authentication request a predetermined number of times and, if the person is not

yet acknowledged, access to the managed data or areas is rejected.

It is desirable that the personal information input means, which is used to select a person's
5   registered finger image from the database, not be a keyboard but a non-contact device. For example, personal information such as a name or a password, or a keyword that is known only to the person, may be input via voice or, alternatively, stored on a non-contact IC
10 card. This type of input means makes it possible to build a personal identification system that takes advantage of non-contact features. This processing may be done independently by the CPU of the identification system or by an online system via computers.

15   An image to be authenticated is stored on a fixed medium connected to the authentication server, a medium containing semiconductor memory, or a portable medium such as a floppy disk. This method eliminates the need for keyboard operation on a banking ATM,
20 solves the problems associated with a contact input device, and relieves a maintenance nuisance. The advantages described above make this method suitable for gaining access to personal information in an electronic government or for authentication in online
25 transactions.
(Second embodiment)

In the first embodiment, a finger is imaged with one CCD camera. A finger may also be imaged with

a plurality of CCD cameras during authentication or
image capturing to increase the performance of
identification.

5   FIG. 5 shows the arrangement of this embodi-
ment where a plurality of CCD cameras are used; that
is, a light source 301, a finger 302, and CCD cameras
(303-1 - 303-5) are arranged as shown. In this
embodiment, a plurality of finger vein patterns are
captured from a plurality of directions using a
10   plurality of CCD cameras, and the pattern most similar
to the registered vein pattern is selected for
authentication. Alternatively, a plurality of vein
patterns to be registered are captured and saved as
three-dimensional data and, from these patterns, the
15   pattern most similar to the vein pattern to be
authenticated is selected for authentication. This
method is particularly effective for preventing the
performance of identification from being degraded when
the finger is rotated in the major axis direction and,
20   at the same time, effective for implementing a
complete-non-contact device.

Not only a still image but also a moving
image may be imaged. When imaging and registering a
three-dimensional moving image, a finger is rotated in
25   the configuration, shown in FIG. 3B, which is composed
of the light source LED (301), finger (302), and
imaging device (303). Alternatively, as shown in FIG.
5, a plurality of CCD cameras may be used to capture an

image from a plurality of points. A person is
authenticated either by a two-dimensional image imaged
by the imaging unit in the configuration shown in FIGS.
3A and 3B or by a three-dimensional image imaged by the
5 imaging unit in the configuration shown in FIG. 5.

The image is captured into the processing
unit for use in image operation and authentication.
Because the most similar vein pattern to be registered
or the most similar vein pattern to be authenticated is
10 selected for authentication, this method is advantage-
ous in that the performance of identification is
increased and the image operation load is reduced.
(Third embodiment)

FIGS. 13A-13C are block diagrams showing in
15 detail one example of blood vessel emphasizing process-
ing (corresponds to blocks 1101-1103 in FIG. 11). When
a finger image is received (block 1000 or 1004), edge
detection processing is performed to detect the
location of the finger edge (block 1300). Based on the
20 detected edge location, image rotation processing is
performed so that the image is rotated such that the
finger is inclined at a fixed angle, typically, at an
angle of 0 degree (block 1301). Blood pattern
emphasizing processing is performed for the obtained
25 image (block 1302).

For example, blood pattern enhancement
processing is performed using a filter, such as the one
shown in FIG. 13B, designed to remove high-frequency

components in the major axis direction of the finger, and low-frequency components in the minor axis direction. Filtering may be done either by the convolution operation (formula 1) in the real space or by the

5   multiplication operation in the frequency domain. For the image where the blood vessel pattern is enhanced, the average of the pixel values outside the finger is made equal to the average of the pixel values inside the finger, based on the edge location detected by the

10 edge detection processing (block 1300), as in FIGS. 12A-12G (block 1303). When shifting the average of the pixel values inside the finger to 0, the pixel values outside the edge are set to 0.

Two-dimensional FFT transform operation is

15 performed for the obtained image (block 1103), squaring of respective pixel data of the obtained is performed (block 1304), and then two-dimensional IFFT operation is performed (block 1305). For the obtained result, the parameters for evaluation are calculated (block

20 1306). Because vessels usually run in the major axis direction of the finger rather than in the minor axis direction, the difference in the blood vessel pattern is most reflected in the peak shape in the minor axis direction of the finger in the two-dimensional convolu-

25 tion operation result. Therefore, the parameters for evaluation are calculated, for example, using a kernel composed only of the elements in the minor-axis direction of the finger such as the one shown in FIG.

13C, to perform convolution operation in the real space
or multiplication in the frequency domain.

If the input image is an m × n matrix and the
kernel is a p × 1 matrix, then the result of the

5   calculation of parameters for evaluation is a (m + p
- 1) × n matrix. The maximum value Mx of the resulting
matrix is calculated for each of the registered image
and the image to be authenticated. Let the maximum
value be M1 and M2, respectively. M1 is stored in the

10 database (100).

FIG. 14 is a block diagram showing the
authentication procedure executed after block 1007 when
an image is processed according to the procedure shown
in FIG. 13A. Calculation of parameters for evaluation

15 (block 1403) is executed for the result of the calcula-
tion of correlation between the registered image and
the image to be authenticated. For the calculated
maximum value M, normalization operation (block 1404)
is performed according to the formula (formula 3) based

20 on M1 and M2 described above.

$$M = M_{12}\big/\sqrt{M_1 \times M_2}$$ (Formula 3)

If the calculated value MX of correlation

25 between the registered image and the image to be
authenticated is larger than the threshold Mxo, the
identifee is regarded as valid and is accepted (block
1009). If the value Mx is less than the threshold Mxo,

the identifee is not regarded as valid and is rejected
(block 1010). The threshold Mxo should be statisti-
cally calculated in advance by entering sample images.
When the average of pixel values inside the finger is

5   shifted to 0 as described above, the value of Mxo
ranges from 0.3 to 0.4 but is not limited to this
range.

(Fourth embodiment)

Because a fully non-contact method is not

10 always advantageous in cost, processing time, and
compactness, it is more practical for a device, while
still retaining the non-contact features described
above, to have the minimum positioning parts required
for fixing an imaging region such as a finger or a

15 hand. Note that more bacilli are present on the palm
of a hand of a human being than on the back. There-
fore, even on a device on which the imaging region
contacts the positioning parts, the palm of the hand
should not contact the device. The following describes

20 an example.

FIG. 7 shows a finger positioning method
using air jet instead of the pins in FIGS. 3A and 3B.
Compressed air is jetted from the jet hole (FIG.
7(700), FIG. 8(800)). Numeral 802 indicates an air

25 compressor and a control system, and numeral 801
indicates a compressed-air intake. In FIG. 8, an air
jet from the air jet hole on the palm side of the hand
prevents the palm from contacting the device. At

identification time, a person places his or her hand
naturally in the position where the air jet from the
hole 700 in FIG. 7 does not blow strongly against the
fingers.

5   An optical sensor, which measures the
distance between the device and the palm to check to
see if the height, from the device to the palm, is
correct, is provided to control image capturing. If
the height is incorrect, incorrect-height information

10 is sent to the identifee. Because the palm does not
contact any object as described above, this embodiment
reduces the possibility of bacillus contagion caused by
an unspecified number of persons using the device.
Therefore, it can be said that the method in this

15 embodiment in which the palm does not contact any
object is better than a method in which the palm
contacts the device.

          Winding a palm-contact sheet (900) or
sterilizing the sheet with a ultraviolet light source

20 (901) or a disinfectant (902) allows even a palm-
contact device to take advantage of the identification
system according to the present invention that keeps
the device clean. For full sterilization, an optical-
catalyzed (titanic-oxide) coated sheet is used as the

25 palm-contact sheet (900) and a ultraviolet light is
shown on the sheet. Including this type of sterilizer
keeps the device clean.

          The embodiments described above allow a

reliable, secure, and easy-to-use personal identifica-
tion system to be built. That is, a familiar, forgery-
proof, highly-accurate personal identification system
may be implemented while eliminating or minimizing
5   maintenance management work executed for preventing
contagion caused by dirt on the device or for prevent-
ing errors in obtained data.